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EXAMINER	
VAN, LUAN V	

ART UNIT	PAPER NUMBER
1753	

DATE MAILED: 11/27/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/814,059	KWAK ET AL.	
	Examiner	Art Unit	
	Luan V. Van	1753	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *18 October 2006*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *3,4,6-16,21-23,25 and 26* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *3, 4, 6-16, 21-23, 25-26* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Amendment

Applicant's amendment of October 18, 2006 does not render the application allowable.

The amendment is objected to under 35 U.S.C. 132(a) because it introduces new matter into the disclosure. 35 U.S.C. 132(a) states that no amendment shall introduce new matter into the disclosure of the invention. The added material which is not supported by the original disclosure is as follows: Claims 3, 4, 6-16, 21-23 and 25-26 are amended to recite the limitation of forming "an opening greater than about 3000 Å wide" (independent claim 7) and "the opening having a field area greater than at least 3000 Å" (independent claim 21). The instant specification on page 16, first paragraph, simply states that if copper deposition in the field area is approximately 3000 Å, a partial CMP may optionally be performed. This does not support the limitation of forming an opening greater than about 3000 Å wide or the openings themselves having a field area greater than at least 3000 Å. The disclosure, therefore, does not provide a clear indication to support the amended limitations. Applicant is required to cancel the new matter in the reply to this Office Action.

Status of Objections and Rejections

All rejections from the previous office action are withdrawn in view of Applicant's amendment.

New grounds of rejection under 35 U.S.C. 103(a) are necessitated by the amendments.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 3, 4, 6-16, 21-23 and 25-26 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

Claims 3, 4, 6-16, 21-23 and 25-26 are amended to recite the limitation of forming "an opening greater than about 3000 Å wide" (independent claim 7) and "the opening having a field area greater than at least 3000 Å" (independent claim 21). The instant specification on page 16, first paragraph, simply states that the of copper deposition in a few area is greater than approximately 3000 Å, a partial CMP may optionally be performed. This does not support the limitation of forming an opening greater than about 3000 Å wide or the openings themselves having a field area greater

than at least 3000 Å. The disclosure, therefore, does not provide a clear indication to support the amended limitations.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham* **v.** *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

Claims 3-4, 6-9, 16, 21-23 and 25-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bonkabeta et al. in view of Mayer et al. and Taylor.

Regarding claim 7, Bonkabeta et al. teach a method of planarizing a metal layer on a semiconductor substrate, the method comprising: forming a trench or via (paragraph 31) in a dielectric layer of the semiconductor substrate; forming the metal layer (paragraph 34) on the dielectric layer such that the metal layer at least fills the trenches or vias; immersing the substrate (paragraph 32) in an electrolyte plating solution having organic additives (paragraph 34), the organic additives comprising at

least one of plating accelerators, plating suppressors, and plating levelers (such as the polymer phenazonium derivatives), and removing the excess portions of the metal layer by performing sequentially electropolishing followed by electroplating (figure 6a), wherein the polishing, plating, and relaxation operations comprise one cycle of a pass and wherein the method comprises at least two passes performed sequentially (see figure 6 a).

Bonkabeta et al. differ from the instant claims in that the reference does not explicitly discuss the relaxation period, although Bonkabeta et al. show a time period (shown as a gap in figure 6a) of having no current in between the plurality of electrodepositing an electropolishing pulses.

However, even assuming that Bonkabeta et al. does not teach the relaxation period, using a relaxation time period is conventionally known in the art. For example, Mayer et al. teach a method in which multiple cathodic pulses (i.e., electroplating) with off times (i.e., relaxation operations) and multiple anodic pulses (i.e., electropolishing) with off times (column 20 lines 35-39). Further, Mayer et al. explains that no current is supplied during an off time period during which relaxation and replenishment of additive and copper ions in the via occurs (column 20 lines 41-45).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Bonkabeta et al. by using relaxation period of Mayer et al., because it would allow the replenishment of additive and copper ions in the via, thus enabling the additives to equilibrate.

Although Bonkabeta et al. teach that in conventional damascene processes the excess electroplated metal is remove by chemical mechanical polishing (paragraphs 13-14 of Bonkabeta et al.), Bonkabeta et al. does not explicitly teach combining CMP and electropolishing (i.e., electroplating and deplating). Bonkabeta et al. also differ from the instant claims in that the reference does not explicitly teach the specific feature size of the instant claim.

Taylor teaches that it is conventionally known to perform CMP and electropolishing to remove excess electroplated metal (see paragraph 33 and Example).

Mayer et al. teach typical feature widths in current integrated circuits are around 3000-4000 Å (column 3 lines 12-16).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Bonkabeta et al. by using CMP and electropolishing as taught by Taylor, because a CMP process prepares a smooth surface for subsequent processing of the structure, such as additional deposition or electropolishing as suggested by Taylor (paragraph 33). With respect to the order between the CMP step and the electropolishing step, selection of any order of performing process steps is prima facie obvious in the absence of new or unexpected results. See MPEP 2144.04 (IV).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have further modified the method of Bonkabeta et al. by forming the feature size of Mayer et al., because such feature size allows the fabrication of a high-density integrated circuit device.

Regarding claims 8-9, Bonkabeta et al. differ from the instant claims in that the reference does not explicitly disclose the specific ratio of electropolishing rate to electroplating rate of the instant claim nor decreasing the ratio of electropolishing rate to electroplating rate to about 1.0.

However, Bonkabeta et al. teach that in electropolishing the integral of the amperage of an electropolishing/electroplating sequence (i.e., pass) must be less than zero (paragraph 55), since the integral of the electropolishing amperage is greater than the integral of the electroplating amperage. Therefore, the ratio of the integral of the electropolishing amperage to that of the electroplating amperage must be greater than 1.0. In order for electropolishing or net removal of metal to occur, the electropolishing rate to electroplating rate ratio must be greater than 1.0. Since Bonkabeta et al. teach that the performance of their method may be influenced by process parameters such as "temperature of the electrolyte, the time dependence of applied currents, in particular amperages and durations of pulses, numbers of applied pulses and angular frequencies, the geometrical arrangement of components of the plating cell, concentrations of components of the electrolyte, in particular concentrations of conductor metal ions and additives, and the conductivity of the electrolyte" (paragraph 62), it would have been obvious to one having ordinary skill to have optimized through routine experimentation the ratio of the electropolishing rate to electroplating rate to that of the instant claim in order to reduce the total process time to deposit the metal layer, the likelihood of the formation of trapped voids filled with electrolyte in narrow vias and the roughness of the metal layer which is obtained after the electropolishing process

(paragraph 63). It would have been obvious to one having ordinary skill in the art at the time the invention was made to have further modified the method of Bonkabeta et al. by reducing the ratio of the electropolishing rate to electroplating rate to about 1.0 when the process is about complete in order to prevent over polishing of the metal layer. Furthermore, it would not be desirable to reduce the ratio to less than 1 unless net deposition of metal is desired.

Regarding claim 3, Bonkabeta et al. teach the concentrations of the organic additives are selected such that the plating rate is greater than the electropolishing rate in a topography dependant fashion, since the plating method and composition (paragraph 34) of Bonkabeta et al. is same as that of the instant claims.

Regarding claim 4, Bonkabeta et al. teach the topogaphy dependant fashion comprises increasing the rate of plating at corners of trenches or vias, since the plating method and composition (paragraph 34) of Bonkabeta et al. is same as that of the instant claims.

Regarding claim 6, Bonkabeta et al. teach the removal rate of electropolishing is controlled by one of adjusting the voltage applied (or amperage, paragraph 44) to the electrodes in the electrolytic solution and the duration (paragraph 45) of the applied voltage.

Regarding claim 16, Bonkabeta et al. teach using the wafer wide polisher 103 (figure 1).

Regarding claim 21-23, Bonkabeta et al. teach a method of planarizing a metal layer on a semiconductor substrate, the method comprising: providing a semiconductor

substrate having a trench or via (paragraph 31) in a dielectric layer of the substrate; filling the trenches and vias with a metal layer (paragraph 34); spraying the substrate (paragraph 69) in an electrolyte plating solution having organic additives (paragraph 34), the organic additives comprising at least one of plating accelerators, plating suppressors, and plating levelers (such as the polymer phenazonium derivatives), and planarizing the metal layer by implementing a series of pulses comprising sequential electropolishing 601 followed by electroplating 605 (figure 6a). Bonkabeta et al. further teach that in electropolishing the integral of the amperage of an electropolishing/electroplating sequence (i.e., pass) must be less than zero (paragraph 55), since the integral of the electropolishing amperage is greater than the integral of the electroplating amperage. Therefore, the ratio of the integral of the electropolishing amperage to that of the electroplating amperage must be greater than 1.0. In order for electropolishing or net removal of metal to occur, the electropolishing rate to electroplating rate ratio must be greater than 1.0.

Bonkabeta et al. differ from the instant claims in that the reference does not explicitly disclose the specific ratio of electropolishing rate to electroplating rate of the instant claim nor decreasing the ratio of electropolishing rate to electroplating rate to about 1.0. Bonkabeta et al. also differ from the instant claims in that the reference does not explicitly discuss the relaxation period, although Bonkabeta et al. show a time period (shown as a gap in figure 6a) of having no current in between the plurality of electrodepositing an electropolishing pulses.

However, even assuming that Bonkabeta et al. does not teach the relaxation period, using a relaxation time period is conventionally known in the art. For example, Mayer et al. teach a method in which multiple cathodic pulses (i.e., electroplating) with off times (i.e., relaxation operations) and multiple anodic pulses (i.e., electropolishing) with off times (column 20 lines 35-39). Further, Mayer et al. explains that no current is supplied during an off time period during which relaxation and replenishment of additive and copper ions in the via occurs (column 20 lines 41-45).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Bonkabeta et al. by using relaxation period of Mayer et al., because it would allow the replenishment of additive and copper ions in the via, thus enabling the additives to equilibrate.

Since Bonkabeta et al. teach that the performance of their method may be influenced by process parameters such as "temperature of the electrolyte, the time dependence of applied currents, in particular amperages and durations of pulses, numbers of applied pulses and angular frequencies, the geometrical arrangement of components of the plating cell, concentrations of components of the electrolyte, in particular concentrations of conductor metal ions and additives, and the conductivity of the electrolyte" (paragraph 62), it would have been obvious to one having ordinary skill to have optimized through routine experimentation the ratio of the electropolishing rate to electroplating rate to that of the instant claim in order to reduce the total process time to deposit the metal layer, the likelihood of the formation of trapped voids filled with electrolyte in narrow vias and the roughness of the metal layer which is obtained after

the electropolishing process (paragraph 63). It would have been obvious to one having ordinary skill in the art at the time the invention was made to have further modified the method of Bonkabeta et al. by reducing the ratio of the electropolishing rate to electroplating rate to about 1.0 when the process is about complete in order to prevent over polishing of the metal layer. Furthermore, it would not be desirable to reduce the ratio to less than 1 unless net deposition of metal is desired. With respect to the variations in the localized polishing rates and plating rates (claim 21), the method of Bonkabeta et al. would inherently perform the same processes, since Bonkabeta et al. use the same additives and sequential planarizing process have a electropolishing rate to electroplating rate ratio of greater than 1.0 as those of the instant claim as addressed above.

Although Bonkabeta et al. teach that in conventional damascene processes the excess electroplated metal is remove by chemical mechanical polishing (paragraphs 13-14 of Bonkabeta et al.), Bonkabeta et al. does not explicitly teach combining CMP and electropolishing (i.e., electroplating and deplating). Bonkabeta et al. also differ from the instant claims in that the reference does not explicitly teach the specific feature size of the instant claim.

Taylor teaches that it is conventionally known to perform CMP and electropolishing to remove excess electroplated metal (see paragraph 33 and Example).

Mayer et al. teach typical feature widths in current integrated circuits are around 3000-4000 Å (column 3 lines 12-16).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method of Bonkabeta et al. by using CMP and electropolishing as taught by Taylor, because a CMP process prepares a smooth surface for subsequent processing of the structure, such as additional deposition or electropolishing as suggested by Taylor (paragraph 33). With respect to the order between the CMP step and the electropolishing step, selection of any order of performing process steps is prima facie obvious in the absence of new or unexpected results. See MPEP 2144.04 (IV).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have further modified the method of Bonkabeta et al. by forming the feature size of Mayer et al., because such feature size allows the fabrication of a high-density integrated circuit device.

Regarding claims 25-26, Bonkabeta et al. teach the organic additives include bis-3-sulfopropyl disulfide (paragraph 34).

Claims 10-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bonkabeta et al. in view of Mayer et al. and Taylor, and further in view of Reid et al.

Bonkabeta et al., Mayer et al. and Taylor teach the method as described above. The difference between the reference to Bonkabeta et al. and the instant claims is that the reference does not explicitly teach the specific concentrations of the additives of the instant claims, although Bonkabeta et al. disclose that the performance (i.e., the likelihood of void formation in the vias and the roughness of the metal layer, paragraph

63) can be influenced by process parameters such as "concentrations of components of the electrolyte, in particular concentration of conductor metal ions and additives" (paragraph 62) etc.

Reid et al. teach an electroplating method wherein the solution comprises: a leveler at a concentration of between about 0.5-8 ml/L (Table 1); a suppressor at a concentration of between about 1-6 ml/L; and an accelerator at a concentration of between about 0.5-8 ml/L. The ranges of concentration as taught by Reid et al. are within the ranges of the instant claims.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the electroplating method of Bonkabeta et al., Mayer et al. and Taylor by using additive concentrations of Reid et al., because such concentrations are suitable for electroplating to produce metal films and features without voids or defects (paragraph 7).

Claims 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bonkabeta et al. in view of Mayer et al. and Taylor, and further in view of Datta et al.

Bonkabeta et al. teach the method as described above. The difference between the reference to Bonkabeta et al. and the instant claims is that the reference teach a spray of electrolyte (paragraph 69) but does not explicitly teach moving the spray from the center to the edge of the wafer (claim 15).

Datta et al. teach an electropolishing process using a linear electrode with a nozzle assembly which is scanned slowly back-and-forth over the anode, parallel to the substrate surface (column 8 lines 43-45).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the electroplating method of Bonkabeta et al., Mayer et al. and Taylor by moving the spray across the substrate as taught by Datta et al., because it would enable metal to be removed at a high rate of speed (column 10 lines 22-24).

Response to Arguments

Applicants' arguments with respect to the feature size and CMP step have been considered but are moot in view of the new ground(s) of rejection.

In the arguments presented on page 8 of the amendment, the applicant argues that the organic additive bis (3-sulfopropyl) disulfide in claims 25 and 26 is different from the bis (3-sulfopropyl) disodium sulfonate of Bonkabeta et al. The examiner acknowledges that they may be structurally different. However, since these organic additives are used as accelerators and hence sharing similar properties and utilities, it would have been obvious to one having ordinary skill in the art to use a structurally similar specie to those in the prior art. See MPEP 2144.08(d).

The prior art made of record and not relied upon is considered pertinent to the applicant's disclosure. Nakamura et al. teach bis (3-sulfopropyl) disulfide (paragraph 16).

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Luan V. Van whose telephone number is 571-272-8521. The examiner can normally be reached on M-F 9:30-6:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on 571-272-1342. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

LVV
November 16, 2006

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